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Stock status of Atlantic salmon from Conne River, SFA 11, Newfoundland, 1995

J. B. Dempson and G. Furey
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

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Abstract

Results obtained from a fish counting fence provided the basis for the assessment of the Conne River Atlantic salmon stock in 1995. Returns to home waters (river and estuary) were 3502 salmon < 63 cm in length and 110 salmon ≥ 63 cm in size. This represented an increase of 128% for small salmon in comparison with 1994. Large salmon returns increased by 10% from 1994. Sea survival increased to the highest level since 1989-90 (5.8%). Estimated egg deposition from small salmon was 5.952×10^6 eggs; 76% of the target requirement. The contribution from large salmon was 0.369×10^6 eggs and thus 81% of the required target egg deposition was achieved. An enhancement project was initiated at Conne River in 1994 resulted in the stocking of about 128 thousand fry in 1995. Brood stock was again removed in 1995 for fry stocking in 1996. A mark-recapture study suggested a smolt run in 1995 of 62749 (55300-70197). With survival similar to that of 1994-95, over 3300 fish would be expected to return in 1996. A sea survival of about 7% will be needed in order for total returns to homewaters to meet or exceed 4000 adult salmon.

Résumé

Les résultats obtenus à la barrière de dénombrement ont servi de base à l'évaluation du stock de saumon atlantique de la rivière Conne en 1995. Les retours dans les eaux d'origine (rivière et estuaire) se chiffrent à 3 502 saumons < 63 cm de longueur et 110 saumons ≥ 63 cm de longueur. Cela représente une augmentation de 128 % pour les petits saumons, par rapport à 1994. Les retours de gros saumons ont augmenté de 10 % par rapport à l'année précédente. La survie en mer a atteint le niveau le plus élevé depuis 1989-1990 (5,8 %). La ponte approximative des petits saumons était de $5,952 \times 10^6$ oeufs, soit 76 % des besoins. La contribution des gros saumons était de $0,369 \times 10^6$ oeufs, c'est-à-dire 81 % de l'objectif de ponte cible. Un projet de mise en valeur a été entrepris à la rivière Conne en 1994, et a donné lieu au déversement d'environ 128 000 alevins en 1995. Un stock de reproducteurs a été prélevé encore une fois en 1995 pour le repeuplement en alevins en 1996. Une étude par marquage-recapture prévoit une dévalaison de smolts en 1995 de l'ordre de 62 749 (55 300 - 70 197). Si le taux de survie est semblable à celui de 1994-1995, on s'attend à ce que plus de 3 300 poissons reviennent en 1996. Un taux de survie en mer d'environ 7 % serait nécessaire pour obtenir une remonte totale dans les eaux d'origine équivalente ou supérieure à 4 000 saumons adultes.

Introduction

Conne River, SFA 11 (Fig. 1) flows into Bay d'Espoir on the south coast of insular Newfoundland. It is a sixth-order river with a drainage area of 602 km^2 and a total length of 193 km. Since 1986, a fish counting fence has been operated to enumerate the upstream migrating population of Atlantic salmon (*Salmo salar*). Mark-recapture studies were initiated in 1987 to survey the number of migrating smolts. These operations continued in 1995. Previous estimates of the total return of small salmon have ranged from a low of 1533 in 1994 to 10155 in 1987. Target spawning requirements were met or exceeded from 1986-90, but declined to 40% of the target in 1994 (Dempson 1993; Dempson et al. 1994a; Dempson et al. 1995). Stocking of reared fry in 1995, from brood fish maintained in 1994, would have increased 'equivalent' egg deposition in 1994 to 58% of the target. Smolt production has varied from about 56000 to 75000.

A major change in the management of the Conne River Atlantic salmon stock for 1993 was the complete closure of the recreational fishery. In light of the forecast of low salmon returns in 1994 and 1995, this closure was continued and extended to the Indian Band Council's food fishery.

This paper summarizes smolt production and returns of adult salmon to Conne River in 1995. Biological characteristic data for Atlantic salmon are updated and information on the abundance of rainbow trout (*Oncorhynchus mykiss*) from test fishery surveys are summarized.

Noteworthy events or changes in 1995

The following summarizes noteworthy changes to fishery regulations and other observations/events occurring in 1995:

- recreational and native food fisheries closed for the entire season;
- increase in sea survival to the highest value recorded in five years (5.8%);
- estimated egg deposition double the previous year (1994) with 81% of the current target spawning requirement met;
- net-marked salmon continue to be observed at Conne River;
- first fry stocking (N = 128 thousand) from an enhancement program occurred in 1995.
- capture of Atlantic salmon smolts and adults of farmed (hatchery) origin documented again from Conne River in 1995;
- approximately 5,000 wild salmon smolts were removed from the river and transferred to sea cage holding facilities at Roti Bay.

Methods

1. Landings

In past years, information on recreational catch statistics were collected by Department of Fisheries and Oceans (DFO) Fisheries Officers and guardians and processed by DFO Science Branch personnel. Landings from the native food fishery were obtained from the Conne River Native Band Council.

2. Biological characteristics

Biological characteristic information on adult salmon, including fork length, whole weight, age and sex (internal examination), was obtained in 1995 largely from salmon captured at the fish counting fence and subsequently retained for brood stock use. In contrast with 1994, brood stock fish were captured over most of the main run of salmon. Biological data from Atlantic salmon smolts were again obtained from specimens sampled at the downstream counting fence trap.

Analyses of smolt 'condition' were updated following the general methods outlined in Dempson et al. (1994b). A general linear model was used to examine the response of fish weight, standardized to a common length as:

$$Y_{ij} = \mu + \alpha_i + b \bullet z_{ij} + \epsilon_{ij}$$

where,

Y_{ij} is the response variable, smolt weight,
α_i is a class variable, year,
z_{ij} is the covariate fork length, and
ϵ_{ij} is the error term associated with individual observations.

The model was used to calculate adjusted mean smolt weights by year standardized to the covariate. Additional details regarding the common slope (b) model used are in Dempson et al. (1994b). Weight and length variables were transformed to natural logarithms.

3. Rainbow trout

Rainbow trout, which stray into the Conne River as a result of incidental escapements from local fish farming activities in Bay d' Espoir, were again sampled in 1995. In addition, test fisheries were carried out at various locations in Bay d'Espoir from May 25-31, and again from September 12-18. Eight sets were made during the spring and four sets in September. Surface gill nets with mesh size varying from 76 (3") to 102 mm (4") were used. Effort was expressed in terms of mile-hours, defined as the product of the

length of nets (in international nautical miles) and the time in hours that the nets were fished following Reddin (1991). Thus catch per unit effort is expressed as the number of rainbow trout caught per mile-hour of gear fished.

4. Physical measurements

Water temperature information was obtained from a continuous recording Hugrun thermograph in the lower Conne River (April 28 - October 17). Information on air temperature, precipitation, and discharge were obtained from the Environment Canada, Atmospheric and Environment Service monitoring facility located on the main stem of Conne River, below Conne Pond.

5. Estimated returns and spawning escapement

Adult Atlantic salmon migrants were enumerated at a fish counting fence, located about 1 km upstream from the mouth of the Conne River (Fig. 1), which operated from May 30 to October 16, 1995 (Table 1). The counting fence was monitored as a cooperative project between DFO and the Conne River Indian Band.

During 1995, adult salmon were counted either as they: 1) passed through monitored openings in the fish counting fence; 2) entered the trap directly; or 3) passed through openings in the fish counting fence but were recorded on the video camera system. The video camera system utilized a positive image horizontally directed camera (Panasonic model WV-BD400) positioned on the substrate and angled to view an opening in the fish counting fence. A Panasonic Time Lapse Video Recorder (Model AG 6040) was used to record the video signal from the camera and could also superimpose the time and date thus providing a summary of actual fish passage times. The video system was operated each day generally from early evening until about 0900 hours from June 17 until July 31. Some adult small salmon caught in the fish counting fence trap were transferred to holding cages located about 50 m upstream and maintained as brood stock for artificial propagation.

Total returns (TR) of adult salmon were estimated from:

$$TR = Fc + Mb + Cn$$

where, Fc is the count of fish at the counting fence
Mb is the known mortalities below the counting fence, and
Cn is the estimated number of Conne River origin salmon caught in the native food fishery (0 in 1995).

Spawning escapement (SE) was estimated as:

$$SE = Fr - Ma - Br$$

where, Fr is the number of fish released at the counting fence
Ma is the known number of mortalities above the fence
Br is the number of salmon removed for brood stock use.

Consistent with the practise established in 1991, estimated egg deposition refers to the '<u>potential</u>' deposition relative to the current target. That is, no additional adjustments have been made to account for any unknown or assumed mortality of fish up to the time of spawning and thus the potential egg deposition probably overestimates the actual egg deposition.

As in past years, egg deposition was calculated separately for salmon < 63 cm and salmon ≥ 63 cm and then totaled.

$$\text{Egg deposition} = \text{number of spawners} \times \text{\% female} \times \text{fecundity at size.}$$

An estimate of fecundity was obtained from the relationship derived in 1987 (October 27-30) from ripe salmon (Dempson et al. 1987):

$$\text{Fecundity} = 0.1988(\text{fork length, cm})^{2.3942} \qquad (r^2 = 0.48,\ P < 0.001)$$

where fork length was the mean length of female salmon < 63 cm in size sampled in 1995 ($\bar{x}$ = 49.7 cm, N = 83; includes repeat spawning females < 63 cm) and the percentage female was 77%.

An estimate of the egg deposition from salmon ≥ 63 cm in size was obtained using the same length-fecundity relationship for salmon < 63 cm, with the same data for mean length (67.8 cm) and percent females (71%) as used in past years (Dempson 1989, 1990).

The target spawning requirements have been maintained as in past years at <u>7.8 million eggs</u>, equivalent to about 4000 salmon < 63 cm in size.

6. <u>Net-marked salmon</u>

Surveys of net-marked salmon returning to Conne River were carried out from June 4 - July 21, 1995, but only on those fish clearly observed in the fish counting fence trap.

7. Smolt production

A mark-recapture study was carried out to estimate the smolt production in 1995. The study was similar to those carried out in 1987-94, the design of which is summarized in Dempson and Stansbury (1991) and uses the estimator described in Schwarz and Dempson (1994). One exception, however, was that the downstream smolt trap was monitored 24 hours of the day. This was possible because of the cooperative project with the Conne River Indian Band.

During 1995, 2558 smolts were tagged and released at the upstream partial counting fence site (Fig. 1). At the downstream recapture site, 12260 smolts were caught including 545 tagged smolts.

Results and Discussion

1. Landings

Landings in the recreational fishery are summarized in Table 2. As indicated above, no recreational fishing has been allowed since 1993. In past years, angling exploitation rates varied from 0.181 to 0.285 (Dempson et al. 1994a).

Native food fishery catches are also summarized in Table 2. No fishery occurred in 1994 or 1995 although in past years, the food fishery was estimated to have harvested from 5 to 16% of the total number of small salmon returning to Conne River.

2. Biological characteristics

Tables 3 summarizes annual biological characteristic data for salmon sampled from Conne River (1986-95). Mean weight of 1SW salmon in 1994 and 1995 is lower by comparison with earlier years. During the past two years, length and weigh data have been obtained from fish maintained in cages for brood stock. Thus data are recorded in September and not in June or July as in past years. Biological characteristics of the native food fishery catch have been provided in past reports (see Dempson et al. 1995).

Figure 2 illustrates the run timing of smolts and adult small salmon at Conne River. Variability in run timing is apparent for both groups with up to a 15 day difference in the 25th percentile of the run of either life stage. Median dates of the smolt and adult run were typically later during the four years 1991-93 in comparison with the pre-1990 period. During 1995, median run timing for smolts was the earliest since 1990. Timing of the adult run was generally similar to the past three years (1992-94) but still later than the 1986-89 period when returns to home waters was considerably greater.

The analysis of smolt condition indicated significant differences among years ($F = 34.82$, $P = 0.0$) (Fig. 3). Lowest condition was in 1992 followed by 1994, 1990, and 1991. Previously, years in which smolts had a higher condition were those that were generally associated with warmer spring temperatures (Fig. 3). Also, there was an indication that smolt condition was associated with subsequent sea survival, as higher survival of smolts occurred in years where condition was greater (Fig. 3). This pattern was not consistent with results obtained in 1995. First, the temperature 'index' was the coldest recorded in 1995 yet run timing was earlier than in the past few years. Sea survival increased to 5.8%, the highest value in five years although condition in 1994 was among the lower values. We note that smolt condition in 1995 was the third highest recorded. Smolt run timing is still negatively associated with the percent survival to small salmon ($r = -0.853$).

The following text table summarizes the air temperature index, smolt run timing statistic (day of the year) and percent survival from smolt to small salmon.

Year	Air temperature index (April 1-May 15)	Median Day run timing	% Survival
1987	5.48	Day 131	10.2
1988	4.77	136	7.6
1989	4.08	138	7.3
1990	3.46	138	4.2
1991	2.87	141	3.4
1992	2.36	145	4.0
1993	2.34	143	2.7
1994	2.69	142	5.8
1995	1.80	139	

3. Rainbow trout

Records have been kept on the numbers of rainbow trout that have been encountered at Conne River during the course of field activities. This was because of the increased production of rainbow trout at sea farming sites in the Bay d'Espoir area, and the potential impact this could have on wild Atlantic salmon stocks in the vicinity. Summaries of known occurrences for past years are reported in Dempson et al. (1994a and 1995). Information for 1995 is updated in Table 4. Additional rainbow trout were observed during the course of periodic snorkling observations in the lower river or as they were identified from the video camera recordings.

Results of the spring and fall test fisheries are summarized in tables 5 and 6. A total of 33 trout were caught during the spring. No fish were captured in the 'inner bay' (inside of St. Joseph's). Trout were caught at sets outside of Morrisville

(entrance to Conne River estuary), between Tickle Head and Eads Point, northwest of St. Albans, and at Frenchmans Head, outside of St. Albans towards Roti Bay. Fish ranged in length from 285 to 445 mm (mean = 380 mm). Catch rates (CUE) varied from 0 to 6.395, with an overall average CUE of 1.575. Using only those sets where rainbow were caught, then the average CUE increased to 4.201.

Test fishery results during the fall differed considerably from those during the spring. No sets were made in the 'inside' areas. A total of 164 rainbow trout were caught. Lengths ranged from 290 to 480 mm (mean 350 mm). Corresponding whole weights varied from 0.3 to 1.8 kg. Fall catch rates varied from 8.231 to 29.639, with an overall mean CUE of 16.402.

No comparable studies have been carried out previously. However, these results may be interpreted in view of Reddin's (1991) results for postsmolts in the Labrador Sea. In 1987, postsmolt catch rates ranged from 0 to 1.53 (mean = 0.23) while older salmon captured had an average CUE of 0.81 (Reddin 1991). In 1988, catch rates for postsmolts ranged from 0-4.20 (mean = 1.55). Reddin concluded that "*The high catch rates compared with catch rates from Greenland suggest that the population of postsmolts in the Labrador Sea may be large.*" Given the catch rates of rainbow trout in Bay d'Espoir, one may be tempted to conclude that they are quite abundant. Sticklebacks were the most common food item in the rainbow trout stomachs. No evidence for predation on salmon was found.

4. Estimated returns and spawning escapement

There were 3500 salmon < 63 cm and 110 salmon ≥ 63 cm counted at the fish counting fence on Conne River in 1995 (Table 7 and 8). This represents an increase of 128% in the number of small salmon in comparison with 1994. Large salmon numbers increased by 10% from the previous year. The single largest daily run occurred on July 5 (295 fish). In past years, daily counts of over 1000 salmon have occurred (Fig. 4). Only 12 small salmon were enumerated after July 31.

Partitioning the count of salmon among the various ways fish were enumerated in 1995 is as follows:

	Small Salmon		Large Salmon	
	N	%	N	%
Fence opening	96	3	5	5
Counting fence trap	1647	47	61	55
Video camera chamber	1757	50	44	40
Total	3500	100	110	100

With respect to the video camera system, salmon generally migrated all night long. The period from 2230 to 0229 hours accounted for 54% of the total. This pattern of movement was consistent with that observed at Conne River in 1993 and 1994. A total of 1607 fish were associated with time of fish passage as follows:

Time (hours)	Number of fish	%
2030 - 2229	154	10
2230 - 0029	431	27
0030 - 0229	546	34
0230 - 0429	425	26
0430 - 0900	51	3

Total returns of adult salmon to Conne River in 1995 are summarized in Tables 7 and 8 for small and large salmon, respectively. Returns of salmon to Conne River in 1995 were forecast to be below target. Dempson and Reddin (1995) have examined various factors that may have been contributing to the low returns to Conne River.

Total returns of small salmon (3502) were 128% higher than in 1994 while large salmon returns (110) increased by 10%. Sea survival of smolts has changed from 2.7% (2.6-3.0%) in 1994 to 5.8% (5.2-6.5%) (Table 9). This represents the highest survival recorded in five years.

Potential spawning escapement in 1995 was estimated to be 3376 small salmon and 108 large salmon (Tables 7 and 8). Mean number of eggs per female was 2290 using size data from 1995. With 77% of the run estimated to have been female salmon, the number of eggs per fish is 1763. Estimated total number of eggs deposited was:

small salmon = 5.952 million eggs

large salmon = 0.369 million eggs

for a total natural egg deposition of 6.321 million, or 81% of the current target egg requirement and a 103% increase in egg deposition from 1994.

Salmon retained for brood stock in 1995 produced 143,436 eggs that were incubated at the Southwest Brook incubation facility by the community of Conne River. Egg-to-fry survival from an incubator is commonly about 85% while wild survival is 10% (V. Pepper, DFO St. John's, personal communication). By extrapolating to the fry stage, an 'equivalency' in terms of the number of wild eggs that would have had to have been spawned can be estimated

given the numbers of fry that were produced. In doing this, the estimated egg deposition at Conne River in 1995 would increase by approximately 1.219 million eggs [(143436 x 0.85)/0.10], that would correspondingly increase the egg requirement met to 97% of the target.

From eggs incubated over 1994-95, approximately 128 thousand fry were subsequently stocked back into Conne River (all into Twillick Brook). About 40,000 of these were stocked as fed fall fingerlings. All fall fingerlings were adipose fin clipped.

Relationships between estimated egg deposition and subsequent smolt output, and estimated smolt output with adult returns are based on limited data and as such, are not conclusive (Fig. 5). At best, higher egg depositions produced more smolt but the first complete (to river age 4) smolt output from a low egg deposition (4 million eggs in 1991) will not be apparent until 1996. Moderate to high numbers of returning adults corresponded with moderate to higher numbers of migrating smolts in the previous year (Fig. 5). Low returns of adults were obtained over the entire range of smolt migrants. We still caution, however, that it is premature to draw any conclusions from these limited data.

Estimates of egg-to-smolt survival are now available for five year-classes (1986 to 1990; the 1990 year-class complete only to age 4 smolts in 1995). These values, by year-class, are:

Year-class (eggs)	Estimated egg deposition	Smolt Production	Survival (%)	Eggs per 100 m^2
1986	11,340,000	56,873	0.50	860
1987	16,730,000	76,655	0.46	1269
1988	12,420,000	65,038	0.52	942
1989	8,040,000	55,335	0.68	610
1990	8,730,000	66,827	0.77	662
1991	3,980,000			302

Egg-to-smolt survival, while increasing, is still less than 1%. Egg deposition in 1991 was approximately 4 million eggs. Smolts produced to date from the 1991 year class are now complete only to age 3. However, egg-to-smolt survival is already 1.1% and could approach 1.5% if age 4 smolts in 1996 are comparable with the average production from 1989-1995 (15,504). We note that, relative to the estimated 13,180 units (1 unit = 100 m^2) of rearing habitat in the Conne River system, egg deposition rates per unit have ranged from 610 to 1269, coinciding with egg-to-smolt survivals of 0.50 to 0.77%. With the 1991 egg deposition and survival to age 3 smolts already at 1.1%, it is interesting to note that the egg deposition rate per 100 m^2 in this year was only 302.

5. Net-marked salmon

The following summarizes observations of net marked fish at Conne River during 1995.

Date	Number of fish observed	Number scarred	Percent Scarred
June 4-16	220	17	7.7
June 17-21	184	9	4.9
June 22-26	264	23	8.7
June 27-July 1	95	10	10.5
July 2-6	371	22	5.9
July 7-11	72	5	6.9
July 13-21	60	4	6.7
Total	1266	90	7.1

Numbers of net marked salmon varied on each occasion with no apparent increasing or decreasing trend. Results are comparable with those obtained in 1994.

6. Smolt production

The estimated number of smolts in 1995 was 62749 (95% confidence limit = 55300-70197) (Table 9); similar to the previous year. The estimated number of smolts in each age group is summarized in Table 10. Sixty-eight percent of the smolts were age 3+, from the 1991 spawning year when only 51% of the target was achieved.

Discounting the 5,000 smolt transferred to Roti Bay (see below), at 4% survival, the approximate average recorded during the past three years, no more than 2300 fish would be expected to return to home waters in 1996. With survival similar to that of 1994-95, over 3300 salmon could return to Conne River. A sea survival of approximately 7% would be required in order for total returns to meet or exceed the current target requirement of 4000 fish. Sea survivals of 7-10% have been recorded at Conne River in past years but it is stressed that so far, sea survival cannot be predicted with accuracy in advance. At present (March 1996), there is nothing to suggest that survivals approximating 7% will occur. However, early in-season monitoring could be used to advise managers on the status of the run as it progresses.

6.1 Transfer of wild smolt to sea cages at Roti Bay

Five thousand wild smolts were captured at the downstream partial fish counting fence and transferred to sea cages at Roti Bay (May 13-25). These fish were handled a minimum of three times. One hundred tagged smolts (streamer tags) were also included. Initial survival was high. To the end of June 1995, survival of the two groups was comparable (88% for the tagged fish, 85% for the untagged fish; G = 0.951, P = 0.329). Mortalities began to increase and by the end of July, tagged fish had a higher survival (58%) than untagged smolt (34%) (G = 24.117, P = 0.000). To the end of December 1995, survival of the untagged smolts was about 25%. Information on tagged fish was incomplete after the end of July given tag loss that was occurring.

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References

Dempson, J. B. 1989. Assessment of the Atlantic salmon population of Conne River, Newfoundland, in 1989. CAFSAC Res. Doc. 89/76. 26 p.

Dempson, J. B. 1990. Assessment of the Atlantic salmon population of Conne River, Newfoundland, in 1990. CAFSAC Res. Doc. 90/83. 33 p.

Dempson, J. B. 1993. Evaluation of the status of the Atlantic salmon population of Conne River, Newfoundland, in 1992. DFO Atlantic Fisheries Res. Doc. 93/3. 31 p.

Dempson, J. B., G. Furey, and C. Pennell. 1994a. Status of the Atlantic salmon population of Conne River, SFA 11, Newfoundland, in 1993. DFO Atlantic Fisheries Res. Doc. 94/12. 35 p.

Dempson, J. B., M. F. O'Connell, and D. E. Stansbury. 1994b. Analysis of Atlantic salmon (Salmo salar) smolt condition and marine survival; information from two south coast Newfoundland rivers. DFO Atlantic Fisheries Res. Doc. 94/14. 23 p.

Dempson, J. B., T. R. Porter, and G. Furey. 1987. Assessment of the Atlantic salmon population of Conne River, Newfoundland, 1987. CAFSAC Res. Doc. 87/104. 14 p.

Dempson, J. B., D. G. Reddin, G. Furey, and C. Pennell. 1995. Evaluation of Atlantic salmon stock status: Conne River, SFA 11, Newfoundland, 1994. DFO Atlantic Fisheries Res. Doc. 95/77. 44 p.

Dempson, J. B., and D. G. Reddin. 1995. Factors affecting the returns of adult Atlantic salmon, Salmo salar, with emphasis on Conne River. DFO Atlantic Fisheries Res. Doc. 95/78. 27 p.

Dempson, J. B., and D. E. Stansbury. 1991. Using partial counting fences and a two-sample stratified design for mark-recapture estimation of an Atlantic salmon smolt population. N. Amer. J. Fish. Manag. 11: 27-37.

Reddin, D. G. 1991. Postsmolt Atlantic salmon (Salmo salar) in the Labrador sea. Can. J. Fish. Aquat. Sci. 48: 2-6.

Schwarz, C., and J. B. Dempson. 1994. Mark-recapture estimation of a salmon smolt population. Biometrics 50: 98-108.

Table 1. Summary of dates of operation for downstream smolt mark-recapture studies, and upstream adult salmon counts at Conne River, Newfoundland.

Year	Smolt mark-recapture studies		Adult salmon counts	
	Start	Finish	Start	Finish
1986			May 12	Sept 10
1987	April 26	June 16	May 18	Sept 8
1988	May 9	June 14	May 21	Aug 29
1989	May 9	June 15	May 20	Aug 28
1990	May 3	June 20	May 23	Aug 6
1991	May 3	June 16	May 26	Aug 18
1992	May 10	June 15	May 26	Aug 10
1993	May 9	June 14	May 28	July 31
1994	April 28	June 18	June 1	Sept 25
1995	May 2	June 8	May 30	Oct 16 *

* Fence inoperable in 1995 during the following dates:
June 9, 0200-1500 hrs
June 15, 2030 hrs to June 16, 1100 hrs
Sept 11, 0200 to Sept 13, 1400 hrs
Sept 15, 0200 to Sept 17, 1100 hrs
Sept 18, 1900 hrs to Sept 20, 1000 hrs
Sept 27, 1000 hrs to Sept 29, 1600 hrs

Table 2. Atlantic salmon landings (in numbers of fish) in the recreational fishery, 1974-1995, and in the native food fishery, 1986-1995, at Conne River, Newfoundland. Note that both fisheries were closed in 1994-95.

	Recreational Fishery				Native Food Fishery			
	Effort	Salmon catch				Salmon catch		
Year	rod-days	Small	Large	Total	Quota	Small	Large	Total
1974	4033	1988	17	2005				
1975	3800	1903	17	1920				
1976	3894	1931	27	1958				
1977	3375	1665	5	1670				
1978	3122	1735	7	1742				
1979	2147	1010	0	1010				
1980	3512	2238	14	2252				
1981	5029	2691	2	2693				
1982	5268	3302	24	3326				
1983	6972	2192	21	2213				
1984	6709	2343	0	2343				
1985	5202	2729	0	2729				
1986	6038	2060	0	2060	1200	519	3	522
1987	4979	1598	0	1598	1200	18	0	18
1988	5504	1544	0	1544	1200	607	2	609
1989	4414	1036	0	1036	1200	381	1	382
1990	2740	767	0	767	1200	948*	11	11
1991	679	108	0	108	1200	281	3	284
1992	1499	329	0	329	1200	483	5	488
1993	0	0	0	0	500	417	3	420
1994	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0

* Total for 1990 does not include approximately 50 fish found dead and partially destroyed in traps.

Recreational fishery closed in 1993 and 1994. Quotas of 100 and 330 small salmon were in effect in 1991 and 1992, respectively.

Native food fishery closed in 1994 and 1995

Table 3. Summary of biological characteristics for Atlantic salmon samples from Conne River, Newfoundland (SFA 11), 1986-1995.

Lifestage	Year	Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
		N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
Smolt	1986	145	153	12.0	125	210						145	3.25	0.48	2	5		
	1987	271	144	16.5	106	198	271	29.1	9.9	11.5	73.8	271	3.32	0.54	2	5	270	77
	1988	328	147	15.7	102	201	328	32.3	10.4	12.4	78.8	328	3.41	0.51	3	5	327	73
	1989	288	152	21.3	98	265	288	35.0	14	9.8	123.2	288	3.25	0.53	2	5	288	79
	1990	271	148	21.2	100	253	271	30.5	13.1	10.3	122.8	271	3.29	0.49	2	5	271	74
	1991	246	153	19.9	104	244	246	33.5	13.6	12.6	112.5	246	3.19	0.44	2	5	245	66
	1992	169	149	15.6	116	189	169	30.1	8.9	14.9	59.2	169	3.28	0.51	2	5	169	71
	1993	246	149	16.5	114	198	246	31.6	10.3	15.7	71.7	246	3.26	0.45	3	5	246	67
	1994	208	148	15.1	116	190	208	29.6	8.3	16	59.2	208	3.20	0.41	2	4	208	74
	1995	249	143	15.2	103	179	249	28.6	8.3	10.3	50.6	249	3.31	0.51	2	5	249	73
TOTAL		2421	148	17.7	98	265	2276	31.3	11.3	9.8	123.2	2421	3.28	0.50	2	5	2273	73
1 SW	1986	357	506	23.0	440	570	357	1451	220.4	900	2900	357	3.38	0.57	2	5	356	76
	1987	373	509	23.3	430	580	373	1492	247.5	600	2600	373	3.18	0.46	2	5	327	78
	1988	267	506	26.1	440	600	267	1352	226.5	1000	2200	267	3.14	0.42	2	4	261	80
	1989	140	512	23.3	460	580	140	1411	201.7	1000	2000	140	3.18	0.50	2	5	135	79
	1990	174	508	23.4	449	575	142	1454	184.4	1100	2000	174	3.27	0.52	2	5	141	81
	1991	39	514	22.8	455	552	34	1362	172.4	1000	1700	39	3.18	0.39	3	4	33	70
	1992	77	505	22.4	453	580	36	1363	276.1	900	2000	77	3.18	0.53	2	5	43	79
	1993	39	513	30.8	475	620						39	3.05	0.32	2	4		
	1994	73	510	25.8	405	580	69	1272	193.9	800	1800	73	3.12	0.44	1	4	71	75
	1995	111	498	24.8	433	573	107	1144	184.4	800	1700	111	3.14	0.42	2	5	105	77
TOTAL		1650	507	24.3	405	620	1525	1407	239.3	600	2900	1650	3.22	0.49	1	5	1472	78

* Samples of 1SW salmon in 1994 and 1995 were obtained from fish held for brood stock. Thus fish were sampled in September in each of these years.

Table 3. (Continued) Summary of biological characteristics for Atlantic salmon samples from Conne River, Newfoundland (SFA 11), 1986-1995.

Lifestage	Year	Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
		N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
2 SW	1986	1	630				1	2600				1	3.00				1	100
	1989	2	665	21.2	650	680	1	2700				2	3.50	0.71	3	4	1	100
	1992	1	650				1	2700				1	4.00					
	1994	1	700									1	3.00					
	1995	2	735	49.5	700	770						2	3.00	0.00	3	3		
TOTAL		7	683	46.8	630	770	3	2667	57.5	2600	2700	7	3.29	0.49	3	4	2	100
Consecutive Spawning Grilse																		
	1986	1	560				1	1800				1	3.00				1	100
	1987	31	511	24.5	460	576	31	1331	232.3	1020	2100	31	3.61	0.62	2	5	30	100
	1988	5	556	24.1	430	590	5	1640	260.8	1500	2100	5	2.80	0.84	2	4	5	40
	1989	6	575	23.5	550	610	6	1767	233.8	1500	2000	6	3.00	0.00	3	3	6	50
	1990	3	564	51.4	505	601						3	3.33	0.58	3	4		81
	1991	4	586	49.9	548	659	1	1400				4	3.50	0.58	3	4	1	100
	1992	8	581	43.6	530	660						8	3.50	0.53	3	4		
	1993	3	617	56.9	570	680						3	2.67	1.15	2	4		
	1994	15	564	36.1	510	640	14	1714	455.5	1200	2900	15	3.20	0.56	2	4	15	73
	1995	2	547	3.5	544	549	2	1500	141.4	1400	1600	2	3.00	0.00	3	3	2	100
TOTAL		78	548	44.6	460	680	60	1504	345.3	1020	2900	78	3.35	0.64	2	5	60	83
Alternate Spawning Grilse																		
	1986	1	600				1	2400				1	3.00				1	100
	1989	13	683	18.9	660	710	2	3350	212.1	3200	3500	13	3.08	0.28	3	4	2	100
	1991	2	700	29.0	679	720						2	3.50	0.71	3	4		
	1992	8	682	44.4	630	770						8	2.88	0.35	2	3	1	100
	1993	6	675	35.1	640	710						6	3.33	0.52	3	4		
	1994	3	703	45.1	660	750						3	3.00	0.00	3	3		
	1995	5	730	29.2	710	780						5	3.00	0.00	3	3		
TOTAL		38	688	37.4	600	780	3	3033	568.6	2400	3500	38	3.07	0.36	2	4	4	100

Table 4. Summary of rainbow trout occurrences and captures at Conne River, 1995, with corresponding size data where available.

Year	Date	Location/gear	Length (mm)
1995	May 17	Smolt trap	405
	May 17	Smolt trap	365
	May 22	Smolt trap	337
	May 22	Smolt trap	430
	May 26	Smolt trap	336
	June 21	Diving observation (N = 4)	~ 300-400
	July 8	Video camera	
	July 9	Video camera	
	July 9	Fence mortality	414
	July 9	Adult trap	410
	July 9	Adult trap	454
	July 10	Video camera (N = 2)	
	July 14	Diving observation (N = 12)	~ 200-500
	July 17	Video camera (N = 2)	
	August 26	Adult trap	330
	August 30	Fence mortality	~ 350-400
	Sept 1	Adult trap	~ 350-400
	Sept 5	Adult trap	~ 350-400
	Sept 6	Adult trap	~ 350-400
	Sept 6	Adult trap	~ 350-400
	Sept 14	Adult trap	~ 350-400
	Sept 14	Adult trap	~ 350-400
	Sept 17	Adult trap	~ 350-400

Table 5. Results of the spring test fishery for escaped rainbow trout at Bay d'Espoir, May 25-31, 1995.

Set	No. of Nets	Mesh Size	Date net Set	Time Net Set	Date net Hauled	Time Net Hauled	Hours Fished	No. of Rainbow	Effort	Catch per mile-hour
1	1	1 - 3.5"	May 25	1700	May 26	1000	17	0	0.420	0.000
2	2	1 - 3.0" 1 - 4.0"	May 26	1000	May 27	1200	26	0	1.284	0.000
3	1	1 - 3.5"	May 26	1100	May 27	1145	24.75	0	0.611	0.000
4	1	1 - 3.5"	May 27	800	May 27	1045	2.75	0	0.068	0.000
5	1	1 -3.5"	May 27	1100	May 29	745	44.75	3	1.105	2.715
6	2	1 - 3.0" 1 - 4.0"	May 27	1730	May 31	830	87	15	4.296	3.492
7	1	1 - 3.5"	May 28	800	May 28	1030	2.5	0	0.062	0.000
8	2	2 - 3.5"	May 29	830	May 31	800	47.5	15	2.346	6.395
Totals	11						252.25	33	10.191	3.238

Effort units are in mile-hours as per Reddin (1991)
This is the product of the length of nets and the time in hours nets were fished.

Table 6. Results of the fall test fishery for escaped rainbow trout at Bay d'Espoir, September 12-18, 1995.

Set	No. of Nets	Mesh Size	Date net Set	Time Net Set	Date net Hauled	Time Net Hauled	Hours Fished	No. of Rainbow	Effort	Catch per mile-hour
1	2	1 - 3.0" 1 - 4.0"	Sept 12	1130	Sept 16	900	93.5	38	4.617	8.230
2	1	1 - 3.5"	Sept 13	730	Sept 15	1630	45	28	1.111	25.201
3	2	2 - 3.5"	Sept 15	1800	Sept 17	1100	41	60	2.025	29.636
4	2	1 -3.5"	Sept 16	1000	Sept 18	1200	45.5	38	2.247	16.913
Totals	7						225	164	9.999	16.401

Effort units are in mile-hours as per Reddin (1991)
This is the product of the length of nets and the time in hours nets were fished.

Table 7. Total estimated returns of small salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-95.

	Year									
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Returns										
* Food Fishery (estuary)	766	451	506	317	831	234	403	347	0	0
Angling below fence				180	213	70	137	0	0	0
Mortalities below fence	21	17	3	2	3	2	0	1	0	2
Count at fence	7515	9287	7118	4469	4321	2086	1973	2355	1533	3500
Estimated count		400				19	10			
Total Returns	8302	10155	7627	4968	5368	2411	2523	2703	1533	3502
1 - Released at fence	7515	9687	7118	4469	4321	2105	1983	2355	1533	3500
Removals and mortalities										
Mortalities above fence	27	21	7	4	2	5	8	2	5	7
Angling above fence	2060	1598	1544	856	554	38	192	0	0	0
Brood stock removal		245							93	117
2 - Total	2087	1864	1551	860	556	43	200	2	98	124
Spawning escapement										
(1) - (2)	5428	7823	5567	3609	3765	2062	1783	2353	1435	3376
Egg deposition										
in millions of eggs	9.86	14.66	10.65	6.95	7.50	3.68	3.45	4.43	2.78	5.95
% of Target met	126	188	137	89	96	47	44	57	36	76

* Food fishery includes fish caught in the estuary during tagging studies in 1986 and 1987. Proportions of Conne River origin salmon in 1986 and 1987 were 0.792 (N = 967) and 0.914 (N = 493), respectively. For remaing years, the weighted mean (0.833) was used.

Note: Results for 1994 are for wild fish only, and do NOT include any impact of the egg deposition 'equivalency' from fry reared in 1994-95.

Table 8. Total estimated returns of large salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-95. Total estimated egg deposition from small and large salmon are also indicated along with the combined estimate of the percentage of the target spawning requirement met.

	Year									
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Returns										
* Food Fishery (estuary)	14	18	2	1	11	2	4	2	0	0
Angling below fence	0	0	0	0	0	0	0	0	0	0
Mortalities below fence	1	0	0	0	0	0	1	0	0	0
Count at fence	397	498	418	319	361	87	154	98	100	110
Estimated count										
Total Returns	412	516	420	320	372	89	159	100	100	110
1 - Released at fence	397	498	418	319	361	87	154	98	100	110
Removals and mortalities										
Mortalities above fence	1	0	0	0	0	0	1	1	0	2
Angling above fence	0	0	0	0	0	0	0	0	0	0
Brood stock removal		10							1	0
2 - Total	1	10	0	0	0	0	1	1	1	2
Spawning escapement										
(1) - (2)	396	488	418	319	361	87	153	97	99	108
Egg deposition										
in millions of eggs	1.48	2.07	1.77	1.09	1.23	0.30	0.52	0.33	0.34	0.37
% of Target met	19	27	23	14	16	4	7	4	4	5
Total egg deposition - small and large salmon	11.34	16.73	12.42	8.04	8.73	3.98	3.97	4.76	3.12	6.32
Egg deposition per unit fluvial habitat	860	1269	942	610	662	302	301	361	237	480
Total % Target met	145	214	159	103	112	51	51	61	40	81

* Food fishery includes fish caught in the estuary during tagging studies in 1986 and 1987. Proportions of Conne River origin salmon in 1986 and 1987 were 0.792 (N = 967) and 0.914 (N = 493), respectively. For remaining years, the weighted mean (0.833) was used.

One unit of fluvial habitat = 100 m^2.
Conne River has an estimated 13,180 units of accessible fluvial habitat.

Table 9. Estimates of Atlantic salmon smolts from Conne River, 1987 - 1995, along with subsequent survival to both small salmon in year i + 1, and to 1SW salmon (repeat spawning fish omitted).

	Number of smolts			Population estimate			Survival		
	Upper site	Lower site							
Year	Tagged & released	Total number Captured	Tag Recoveries	N	Confidence interval	Coefficient of variation %	% survival to small salmon	Survival range	% survival to 1SW salmon
1987	4975	14314	990	74585	67597-81573	5.1	10.2	9.3-11.3	10.04
1988	3235	19515	1054	65962	59862-71522	4.8	7.6	6.9-8.3	6.94
1989	2699	16928	604	73724	66598-80850	5.1	7.3	6.7-8.1	7.16
1990	3719	13881	945	56943	52315-61571	4.4	4.2	3.9-4.6	4.05
1991	3753	9581	398	74645	62033-87527	9.0	3.4	2.9-4.1	3.23
1992	3758	10229	529	68208	61334-75052	5.4	4.0	3.6-4.4	3.79
1993	2456	15992	735	55765	51666-59864	3.9	2.7	2.6-3.0	2.63
1994	2366	11875	479	60762	53759-67765	6.2	5.8	5.2-6.5	5.66
1995	2558	12260	545	62749*	55300-70197	6.3			

* Of these fish, 5000 smolt were transferred to sea cage holding facilities at Roti Bay

Table 10. Estimated total number of smolts in each age group, Conne River, Newfoundland, 1987-95. Lower chart indicates the percentage of smolts at each river age.

	River age (y)				
Year	2	3	4	5	Total
1987	1492	49226	22375	1492	74585
1988	0	40072	24963	657	65692
1989	2212	52344	17694	1474	73724
1990	569	39861	15944	569	56943
1991	747	59716	13436	746	74645
1992	682	49792	16370	1364	68208
1993	0	41266	14499	0	55765
1994	0	48002	12760	0	60762
1995	627	42670	18825	627	62749

	Percent in each age group				Number of
Year	2	3	4	5	samples
1987	2	66	30	2	271
1988	0	61	38	1	328
1989	3	71	24	2	288
1990	1	70	28	1	271
1991	1	80	18	1	246
1992	1	73	24	2	169
1993	0	74	26	0	246
1994	0	79	21	0	208
1995	1	68	30	1	249

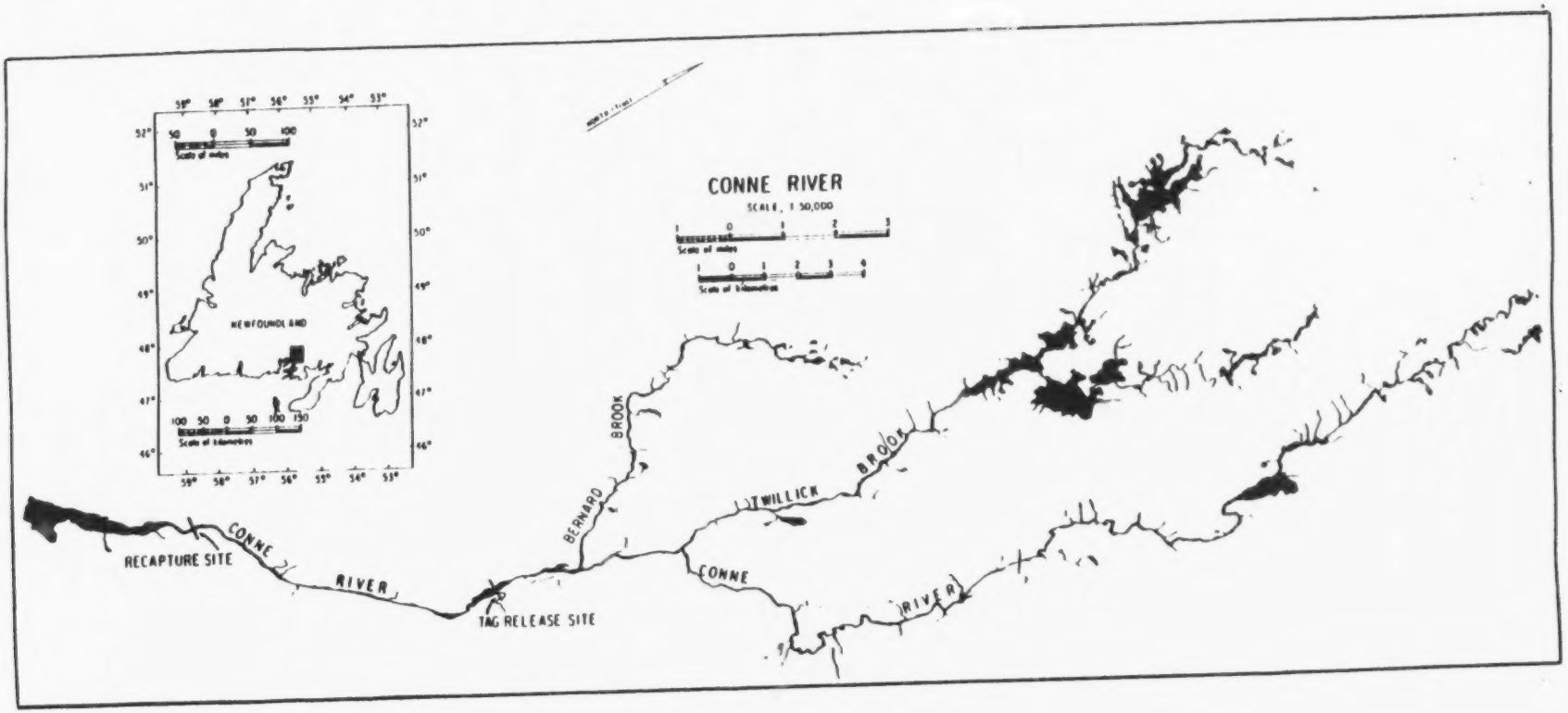

Fig. 1. Conne River, Newfoundland, SFA 11, illustrating the location of the fish counting fences used for the mark-recapture survey. The recapture site is also the location of the upstream adult salmon counting facility.

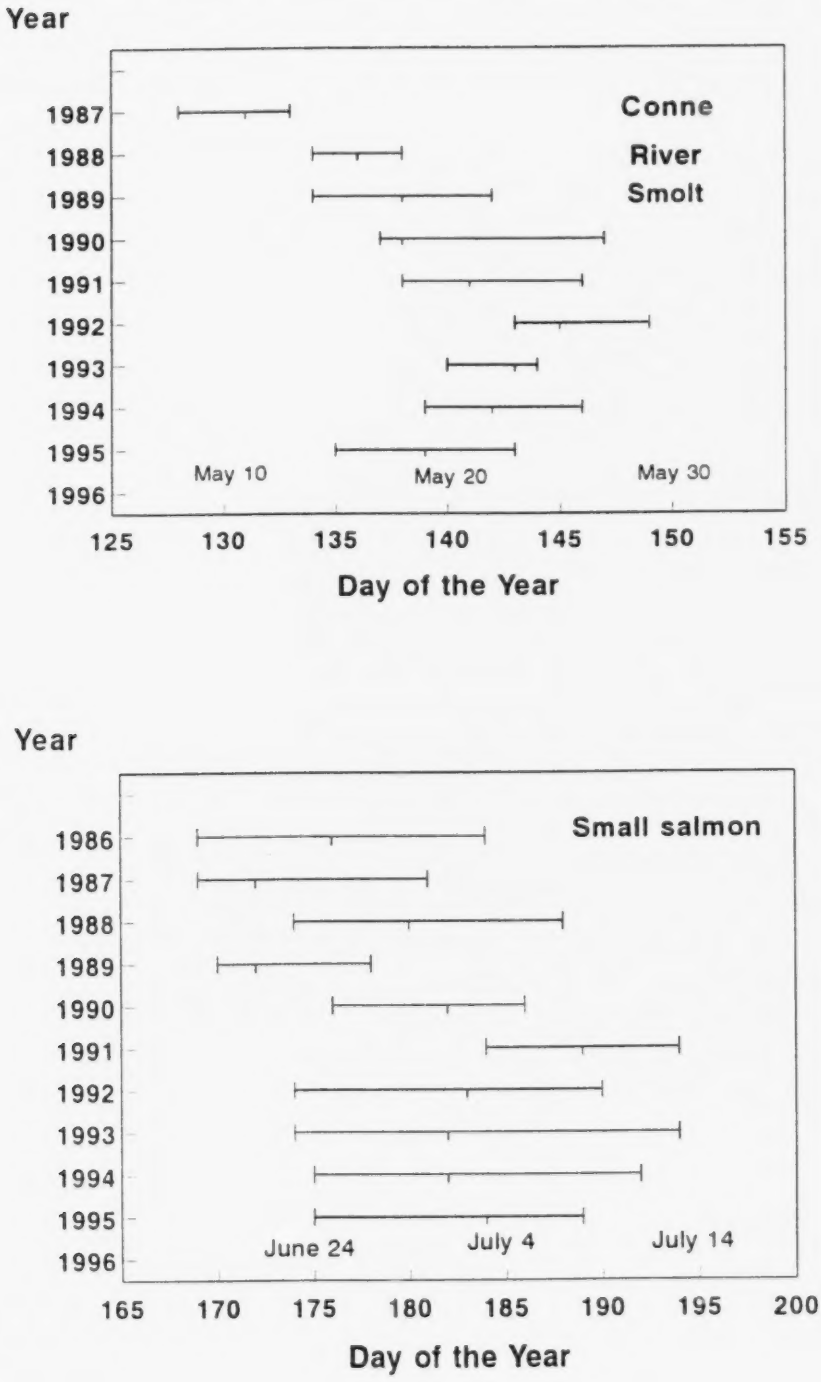

Fig. 2. Run timing of smolt and adult small salmon at Conne River, Newfoundland. The median (50th) point, along with the 25th and 75th percentiles are illustrated.

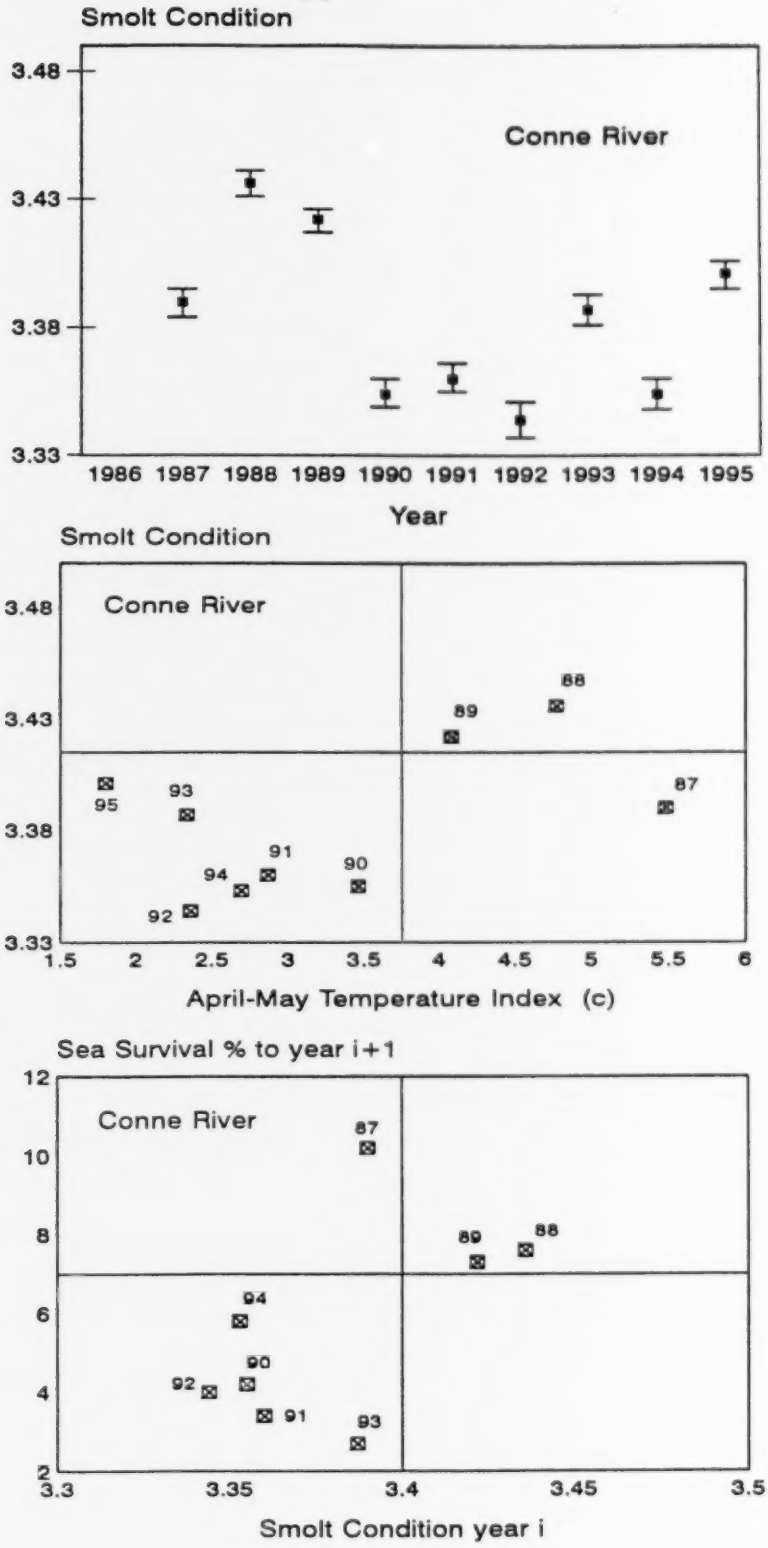

Fig. 3. Index of Conne River smolt condition: varying over years (upper panel); in relation to the April-May air temperature index (middle panel); and as it relates to estimated sea survival of adult salmon returning in the following year (lower panel). Vertical lines in the upper panel represent ± one standard error.

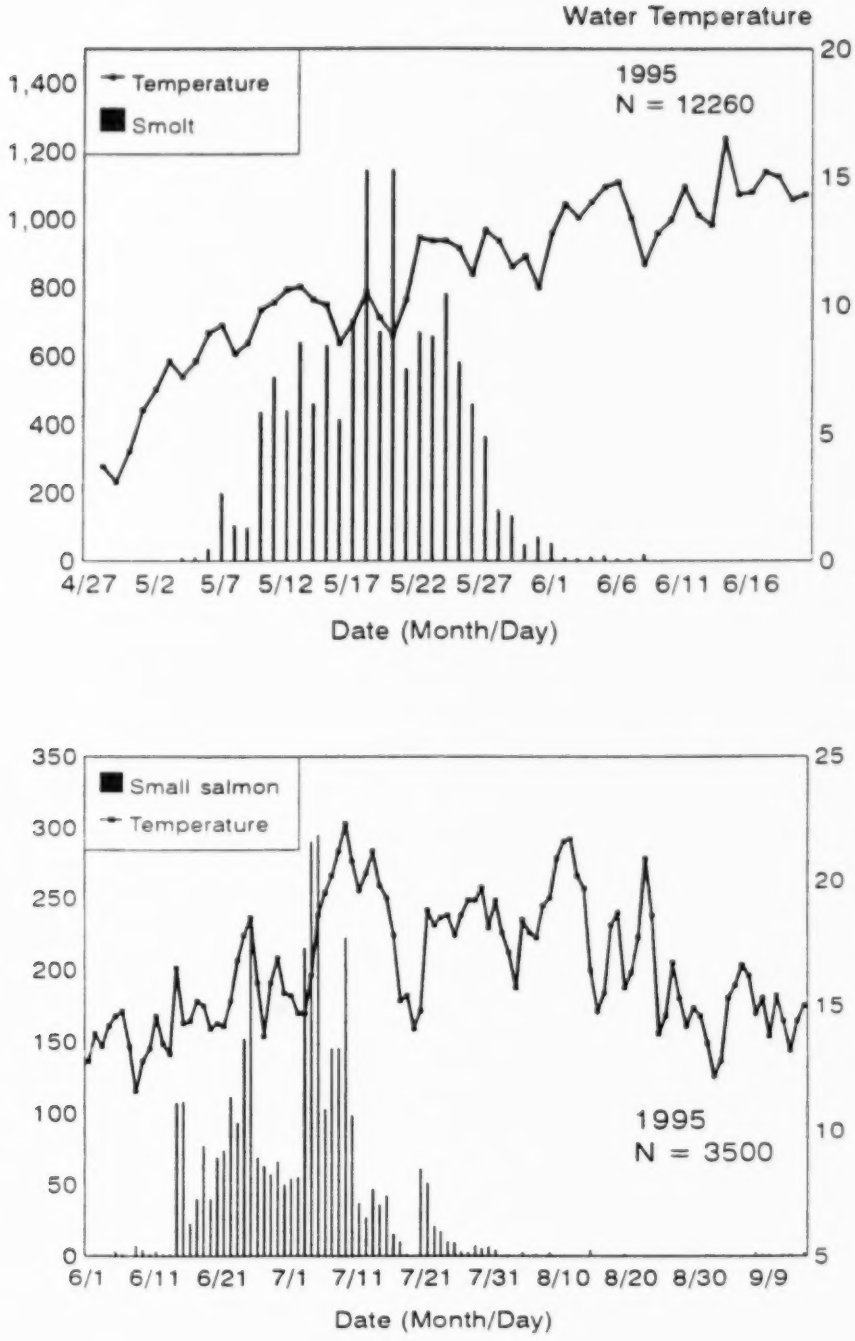

Fig. 4. Daily count of Atlantic salmon smolt at the downstream partial fish counting fence trap (upper panel) and number of adult small salmon returning to the adult fish counting fence trap (lower panel). Mean daily river water temperature indicated on both graphs.

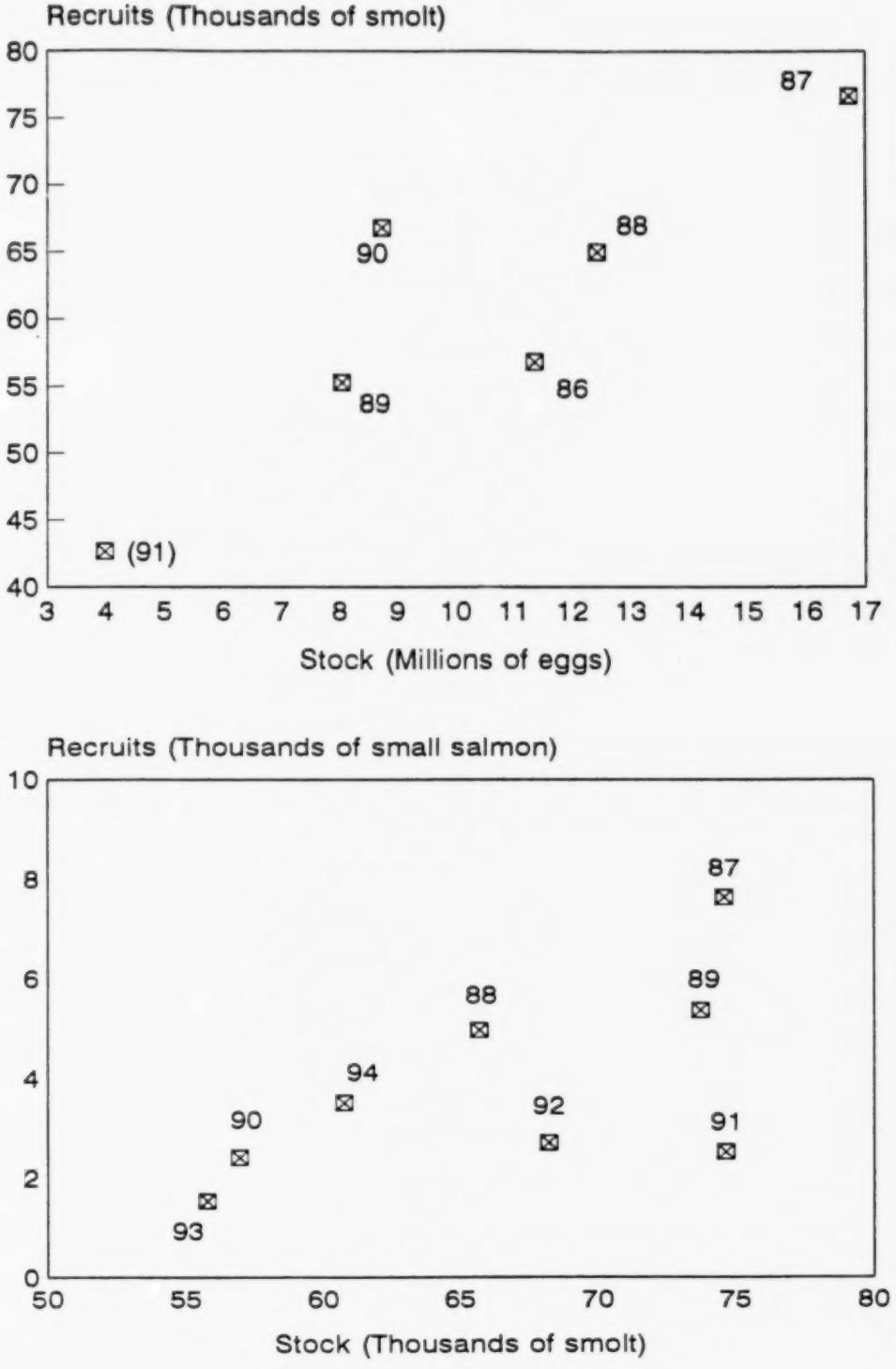

Fig. 5. Relationship between estimated egg deposition and subsequent smolt production, by year class (year of egg deposition indicated, upper panel), and smolt production (year of smolt run) and corresponding return of adult small salmon in the subsequent year (lower panel). Brackets around the 1991 year class in the upper panel indicate incomplete information on number of age 4 smolt which will migrate in 1996.

STOCK: Conne River (SFA 11) **Drainage area:** 602 km^2
TARGET: 7.8 million eggs (~4000 small salmon) calculated as fluvial area x 2.4 eggs/m^2 and egg/recruit applied to total population as derived from assumed commercial exploitation rates.

Year	1990	1991	1992	1993	1994	1995	MIN[1]	MAX[1]	Mean[1]
HARVEST:									
First Peoples' harvest									
Large	11	3	5	3	0	0	0	11	3
Small	948	281	483	417	0	0	18	948	459
Recreational catch									
Small	767	108	329	0	0	0	0	3302	1824
Returns:									
Large	372	89	159	100	100	110	89	516	355
Small	5368	2411	2523	2703	1533	3502	2411	10155	6472
Escapement:									
Large	361	87	153	97	99	108	87	488	345
Small	3765	2062	1783	2353	1435	3376	2062	7823	4709
% Target eggs met:									
	112	51	51	61	40	81	51	214	131

[1] Minimum, maximum and mean recreational catch for period 1974-91; other mean data for 1986-91 to coincide with the pre-moratorium period. Angling catches are DFO statistics. First Peoples' catch in salt water includes some salmon from other rivers. First Peoples' fishery quota of 1200 fish has been in effect since 1986, but reduced to 500 fish for 1993. First Peoples' fishery closed in 1994 and 1995.

Data and methodology: Smolts used in adult forecasts are surveyed by mark-recapture. Returning adult salmon are enumerated at a fish counting fence. A video camera system was introduced in 1993.

State of the stock: Target requirements were met from 1986-90. Only 40-61% of the target was achieved from 1991-1994. This increased to 81% in 1995. Sea survival increased to the highest value in five years (5.8%), but is still low relative to the 1987-90 period. An enhancement project was initiated in 1994 with approximately 128 thousand fry released in 1995. Note that these fry have not been included in terms of the percentage target achieved in the above table.

Forecast: Estimated smolt output in 1995 was 62,749 (55,300-70,197); similar to 1994. At 4% survival, the average recorded during 1990-92, no more than 2,500 fish would be expected to return in 1996. A sea survival of 6.4% will be needed in order for total returns to meet or exceed the 4,000 salmon necessary to reach the target egg deposition. Sea survival of 7-10% has been recorded at Conne River in past years. Survival of salmon appears to be associated with timing of the smolt run and smolt condition. At present, there is nothing to suggest that survivals approximating 7% will occur. In-season monitoring could be used to update managers on changing conditions as the 1996 run progresses.